Vaccine 30 (2012) 6759–6765

Contents lists available at SciVerse ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Seroprevalence of poliovirus antibodies amongst children in Zaria, Northern Nigeria

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ARTICLE INFO

Article history:
Received 22 April 2012
Received in revised form 3 September 2012
Accepted 10 September 2012
Available online 20 September 2012

Keywords:
Poliomyelitis
Seroprevalence
Immunisation
Zaria
Northern Nigeria

ABSTRACT

Background: Poliomyelitis is endemic in Northern Nigeria where there is continuous transmission of wild poliovirus 1 and 3 (WPV1 and 3) and circulating vaccine derived poliovirus 2 (cVDPV2) resulting in a high number of cases of children with acute flaccid paralysis. The seroprevalence of antibodies to polio serotypes which can be used to assess the immune status of children and the effectiveness of the vaccine against poliomyelitis is unknown, despite its endemicity in this part of the world.
Objective: This study aimed to determine the seroprevalence of poliovirus antibodies in children aged 1–10 years in Zaria, Northern Nigeria.
Methods: A descriptive, cross sectional, community based study was undertaken in Zaria, North Western Nigeria between 2008 and 2009. Two hundred and sixty-four (264) children aged 1–10 years were enrolled from two local government in Zaria by multistage random sampling method. Demographic data and polio immunisation history were retrieved from parents and caregivers by an interviewer administered questionnaire. Neutralising antibody titres to polioserotypes 1, 2 and 3 were assayed according to the WHO Manual for the virological investigation of polio. Antibody titres $\geq$1:8 were considered positive.
Results: The mean age of the 264 children studied was 6.25 years. Fifty-five percent of the children were protected against the three polioserotypes, while 86.4%, 76.1% and 77.3% of children had neutralising antibodies to P1, P2 and P3 polioserotypes respectively. 5 (1.9%) of the children had no antibodies to all the three polioserotypes. Polio antibody seropositivity was significantly associated with higher socioeconomic status and immunisation was the single most important determinant of seropositivity to poliovirus serotypes.
Conclusion: Seroprevalence to poliovirus serotypes, though higher than values found in previous studies done in Nigeria, was lower compared to findings in the developed world. The use of more immunogenic vaccines and the balanced use of OPV formulations in SIAs, with further improvements in programme quality could provide the necessary immune booster to make polio eradication in Nigeria a reality.

1. Introduction

In the 20 years since the World Health Organisation adopted a resolution to eradicate poliomyelitis globally by the year 2000, the disease burden has been reduced by more than 99% [1,2]. To date, the virus is endemic in only three countries; Nigeria, Pakistan and Afghanistan which unlike other countries, have never succeeded in interrupting the transmission of wild poliovirus [3]. The most recent country to halt transmission was India which on January 12, 2012 celebrated one full year with no new reported cases [3].

Routine immunisation with the oral poliovirus vaccine was introduced in Nigeria in 1970s with launching of the Expanded Programme on Immunisation in 1979 with an immunisation schedule recommended by the WHO for six childhood vaccines including the oral polio vaccine [4]. The schedule for OPV is at 6, 10 and 14 weeks of age with an extra dose administered at birth called OPV zero, including supplementary immunisation activities targeting children aged less than five years [5]. Nigeria relies on a combination of routine immunisation services using trivalent OPV (tOPV, types 1, 2, and 3) and Supplementary Immunisation Activities (SIAs) to immunise children against polio [6].

There was a resurgence of Acute Flaccid Paralysis cases in 2004–2006 to about 1300–1500 cases worldwide per year as a result of a decline in community acceptance of vaccination in Northern Nigeria in 2002. This followed concerns about the safety of the vaccine raised by influential, political and religious leaders in the region [7]. This led to an epidemic polio resurgence caused by both poliovirus 1 and 3 that spread from Nigeria to neighbouring countries resulting in re-infection of 13 countries and importation to 21 countries. In 2006, Nigeria had the highest number of polio

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http://dx.doi.org/10.1016/j.vaccine.2012.09.023

cases worldwide with 675 (38.6%) of the 1749 Global cases [8]. This led to intensive health education campaigns and multiple SIA (National) and Subnational immunisation days with the involvement of political and religious leaders leading to a decline in the number of polio cases in the second half of 2006.

The use of monovalent and more immunogenic oral polio vaccine (mOPV types 1 and 3) in 2005 [9] has reduced transmission of the virus, and now the recently introduced bivalent OPV 1 and 3 (bOPV) in 2010 will further reduce the transmission of the virus to even lower levels in areas where the disease continues to exist and eradication is a challenge [9].

In Nigeria, confirmed WPV cases decreased by 95%, from 388 in 2009 to 21 in 2010; cVDPV2 cases decreased by 82%, from 154 in 2009 to 27 in 2010 [10]. In 2011 however, there has been a worrisome upward trend, where Nigeria reported 62 WPV cases, a 66% increase compared with 21 WPV cases in 2010 and in 2012 up to date, there have been 48 WPV cases [3]. The WHO Executive board declared polio eradication as a programmatic emergency for global public health in January 2012 [11]. In response to this, the Nigerian Government came up with the Nigerian Polio eradication emergency plan 2012 which provides specificity (activities, targets, deadlines, accountability framework and performance metrics) [12] this includes amongst others, scaling up of new interventions to reach chronically missed children including nomadic populations, strengthened communication response in key areas to address vaccine resistance, incorporating new approaches including GPS and GIS technology in mapping high risk areas and to track movement of vaccination, improving national ownership oversight and accountability and enhancing surveillance [12,13].

Apart from the data available on immunisation coverage and disease incidence, and the research done recently by Baba et al. [14] there is lack of sufficient current information on population immunity in endemic areas which can be used to evaluate the effectiveness of the vaccine through serological surveys and possibly interrupt polio transmission. This study determined the seroprevalence of antibodies against poliovirus serotypes 1, 2 and 3 by evaluating the neutralising antibodies in children within the age at risk, rather than the absolute dependence on theoretical evaluation of the success of the Global polio eradication programme in Nigeria.

2. Materials and methods

2.1. Study design and subjects

This was a one year descriptive, cross sectional and community based study conducted from 2008 to 2009 and subjects were healthy children aged between 1 and 10 years.

2.2. Sampling method

A multistage random sampling technique was employed for subject selection in this study. The two local governments that make up Zaria metropolis, Zaria and Sabon Gari were used as the first stage in a multistage random sampling. The next stage was the selection of wards from the selected local government. Zaria has thirteen wards and Sabon Gari has eleven wards. Two wards were randomly selected from each and one settlement was further randomly selected from each of the selected wards. Panmadina and Kofan jatau were randomly selected in Zaria local government while in Sabon Gari local government, Palladan and Hayin Ojo settlements were selected. The next stage involved was selecting households from the selected settlements. Using a systematic random sampling, a child was selected per household until the sample size was reached. Where there was more than one eligible child per household, a ballot was done to select one child. Where there were no eligible children in the household, the next available household was used. Blood samples were collected from children aged 1 to 10 years after parental consent to enroll in the study. A semi structured questionnaire and child immunisation cards and mothers recall were used to gather information on child's immunisation status. Three trained interviewers carried out interviews with mothers or caregivers. OPV0 is a birth dose of OPV given to neonates in polio endemic countries. If a child had sequentially taken OPV0 to OPV3, he/she was designated as fully vaccinated. If subjects had missing doses, they were classified as partially immunised. Children who had never received any single dose were classified as non-immunised.

2.3. Sites and sample size

A total of 264 blood samples were collected from children from two villages each in Zaria and Sabon Gari local government areas that make up Zaria metropolis based on the Fischers formula below which is used to calculate sample size for populations >10,000

$$n = \frac{Z^2 pq}{d^2} \quad (1)$$

where n is the sample size; Z is the confidence interval (1.96); d is the precision (0.05); $q = l - p$; p = prevalence in target population with characteristic being measured in the study. A prevalence of 80.5% was adopted based on the findings of Aminu [15].

$$n = \frac{(1.96)^2 \times 0.805 \times 0.195}{(0.05)^2} = 241.214 \quad (2)$$

Therefore, sample size = 241.

Percentage non/incomplete response was projected to be about 10% of total sample size, therefore the total sample was increased to 264.

3. Collection preparation and storage of blood samples

About 1–2 ml of blood samples were collected by venepuncture from each child into labelled sterile plain bottles. Samples were immediately stored in a cold box with frozen ice packs and transported to the laboratory. Serum samples were separated by low speed centrifugation at 1000 rpm for 10 min followed by direct removal of the serum using a disposable pipette after retraction of the clot. About 0.5–1 ml of serum was transferred aseptically into labelled sterile cryovials by aspiration with a pasteur pipette and stored at −70 °C until ready for analysis. The process of serum separation from whole blood was done within 24 h of collection.

The samples were inactivated at 56 °C in a water bath prior to use for the neutralisation assay. Virus suspensions of the laboratory strains of the three poliovirus serotypes (Sabin Strains) were prepared in L20B cell line. Challenge dose of $100TCID_{50}$ of poliovirus serotypes 1, 2 and 3 was determined and was used for the neutralisation test by the standard method of constant virus, varying serum dilutions (Beta method) as described in the WHO manual for the virological investigation of polio [16].

This assay was carried out at the National Polio Laboratory at University of Maiduguri Teaching Hospital, Maiduguri.

4. Neutralisation test

Antibodies against poliovirus types 1, 2 and 3 were determined by a microneutralisation assay with prototype Sabin strains, according to the WHO guidelines [16] which measured the ability of a human serum sample to neutralise the infectivity and cytopathic effect of each of the three types of poliovirus on cell cultures in vitro.

Sera were heat-inactivated, diluted two-fold from 1:8 to 1:1024, and then incubated in duplicate for 3 h at 36 °C with 100 × 50% tissue culture infective dose ($TCID_{50}$) of poliovirus antigen. A cell suspension containing 2×10^4 L20B cells/0.1 ml was added. Cell controls and an in-house reference serum sample of known neutralising activity were included in each batch. After incubation for 5 days, the highest dilution of serum that protected 50% of the cultures was recorded. This was examined with an inverted microscope for the presence of CPE. A serum sample was considered positive if antibodies were present at a dilution ≥1:8. Titres were computed as geometric mean titres (GMTs).

5. Ethical consideration

Approval to carry out this study was sought from the Ethical committee of ABUTH, Shika and also from the community heads of Sabon Gari and Zaria local government areas. A written informed consent was also obtained from all caregivers or parents of participants in the study.

6. Statistical analysis

All data were analysed using the SPSS 16 software. Chi square tests were used to determine the association between sociodemographics, polio antibody serotypes and immunisation status in a univariate analysis. A P value < 0.05 was considered statistically significant for all analysis. A multivariate analysis using a logistic regression model to investigate the independent impact of each of the variables was done and was expressed in odds ratio with 95% CI. $P < 0.05$ was considered statistically significant.

7. Results

Two hundred and sixty-four blood samples from children aged 1–10 years were collected between 2008 and 2009. Of these, 60.2% (159) were male and mean age was 6.25 years; there was no statistically significant difference by age between gender ($P = 0.079$). 146 (55.3%) of the 264 children were from Sabon Gari local government area while the remaining 118 children came from Zaria local government. Fathers and mothers with Quranic Education were 136 (51.5%) and 215 (81.4%) respectively while 70 (26%) of the fathers also had secondary education. More than half of the fathers were farmers and majority of the mothers were housewives (65.2)%. Level of mothers and fathers education differed according to residential area. This is shown in Table 1.

8. Polio antibodies seroprevalence

Antibody titres ≥8 were regarded as positive, indicating immunity to poliomyelitis virus, while titres <8 were regarded as negative indicating inadequate immunity to poliomyelitis virus. Out of a total of 264 children, 228 (86.4%), 201 (76.1%) and 204 (77.3%) were seropositive to P1, P2 and P3 polio serotypes respectively at titres ≥1:8.

With regard to seropositivity to more than one serotype, 178 (67.4%) were seropositive to a combination of P1 and P2 serotypes while 162 (61.4%) and 180 (68.2%) were seropositive to a combination of P2 and P3, and P1 and P3 respectively at titres ≥1:8. Using a titre of ≥1:8 as positive, 5 (1.9%) did not have positive titres to any of the three serotypes while 146 (55.3%) had antibodies to all the three serotypes. Out of the five that did not have positive titres 1 (20%) had partial immunisation while 4 (80%) had no history of immunisation. A higher percentage of male children (>55%) had positive titres of ≥1:8 to all the serotypes than the females (<55%). This is shown in Table 2.

Table 1
Demographic data of children aged 1–10 years in Zaria.

Characteristics	$N = 264$	%
Age group		
1–5 years	106	40.2
6–10 years	158	59.8
Sex		
Female	105	39.8
Male	159	60.2
Tribe		
Hausa	227	86.0
Fulani	29	11.0
Ibo	5	1.9
Yoruba	3	1.1
Religion		
Christian	7	2.7
Muslim	257	97.3
Local government area		
Sabon Gari	146	55.3
Zaria	118	44.7
Settlement		
Kofan Jatau	50	18.9
Hayin Ojo	97	36.7
Palladan	49	18.6
Panmadina	68	25.8
Fathers educational status		
Quranic	136	51.5
Primary	35	13.3
Secondary	70	26.5
Tertiary	23	8.7
Mother's educational status		
Quranic	215	81.4
Primary	34	12.9
Secondary	11	4.2
Tertiary	4	1.5
Father's occupation		
Civil Servant	59	22.3
Artisan	13	4.9
Farmer	137	51.9
Trader	44	16.7
Others	11	4.2
Mother's occupation		
Housewife	172	65.2
Petty trader	83	31.4
Farmer	2	0.8
Others	7	2.7
Source of water		
Well	181	68.6
Tap	80	30.3
Borehole		
River/pond	3	
0	1.1	
0		
Type of sewage system		
Pit Latrine	252	95.5
Water system	12	4.5

Table 2
Polio antibodies seroprevalence.

Polio serotypes	Total %
Single polio	
P1	228 (86.4)
P2	201 (76.1)
P3	204 (77.3)
Combined polio	
P1 and P2	178 (67.4)
P2 and P3	162 (61.4)
P1 and P3	180 (68.2)
All polio	
P1, P2 and P3	146 (55.3)
Any polio	
P1 or P2 or P3	259 (98.1)

Table 3
Relationship between demographic data and antibodies to polio serotypes.

	Total population *N*/%	P1 seropositive *N*/%	*P* value (X^2)	P2 seropositive *N*/%	*P* value (X^2)	P3 seropositive *N*/%	*P* value (X^2)
Age group							
1–5	106 (40.2)	90 (84.9)	>0.05	68 (64.2)	<0.0001	78 (73.6)	0.035
6–10	158 (59.8)	138 (87.3)		133 (84.2)		126 (79.7)	
Sex							
Male	105 (39.8)	87 (82.9)	>0.05	86 (81.9)	>0.05	82 (78.1)	>0.05
Female	159 (60.2)	141 (88.7)		115 (72.3)		122 (76.7)	
Tribe							
Fulani	29 (11.0)	23 (79.3)		18 (62.1)		19 (65.5)	
Hausa	227 (86.0)	197 (86.8)		176 (77.5)		177 (78.0)	
Ibo	5 (1.90)	5 (100)	>0.05	4 (80)	>0.05	5 (100)	>0.05
Yoruba	3 (1.10)	3 (100)		3 (100)		3 (100)	
Religion							
Christian	7 (2.7)	7 (100)	>0.05	6 (85.7)	>0.05	7 (100)	>0.05
Muslim	257 (97.3)	221 (86)		195 (75.9)		197 (76.7)	
LGA							
Sabon Gari	146 (53.3)	130 (89.0)	>0.05	126 (86.3)	<0.0001	120 (82.2)	0.034
Zaria	118 (44.7)	98 (83.1)		75 (63.6)		84 (71.2)	
Settlement							
Kofan Jatau	50 (18.9)	47 (94.0)		40 (80.0)		37 (74.0)	
Hayin Ojo	97 (36.7)	89 (91.8)	<0.006	82 (84.5)	<0.0001	84 (86.6)	0.044
Palladan	49 (18.6)	41 (83.7)		44 (89.8)		36 (73.5)	
Pan madina	68 (25.8)	51 (75.0)		35 (51.5)		47 (69.1)	
Fathers education							
Quranic	136 (51.5)	111 (81.6)		93 (68.4)		96 (70.6)	
Primary	35 (31.3)	32 (91.4)	>0.05	27 (77.1)	0.012	23 (65.7)	0.0001
Secondary	70 (56.5)	64 (91.4)		62 (88.6)		66 (94.3)	
Tertiary	23 (8.7)	21 (91.3)		19 (82.6)		19 (82.6)	
Mothers education							
Quranic	215 (81.4)	182 (84.7)		159 (74)		160 (74.4)	
Primary	34 (21.9)	32 (94.1)	>0.05	31 (94.1)	>0.05	30 (88.2)	>0.05
Secondary	11 (4.2)	10 (90.9)		9 (81.8)		11 (100)	
Tertiary	4 (1.5)	4 (100)		2 (50)		3 (75.0)	

9. Relationship between demographic data and antibodies to polio serotypes

The relationship between demographic data and antibodies to polioserotypes is shown in Table 3.

9.1. P1 antibodies seropositivity

The table shows that the children's settlement, water source and immunisation status were the only variables significantly associated with antibodies to P1 serotype. Children resident in Kofan Jatau and Hayin Ojo, had higher P1 antibodies seropositivity of 94% and 91.8% respectively which was significant (*P* value 0.006). Children using well water had a higher P1 antibodies seropositivity of 68.9% which was significant (*P* value < 0.0001). The highest seropositivity to P1 was found in children with complete immunisation (97.3%) and the least in those with no immunisation (43.8%). These differences were significant (*P* value < 0.0001).

9.2. P2 antibodies seropositivity

The variables significantly associated with antibodies to P2 serotype were age group, local government area, settlement, father's education, water source and immunisation status. Children in the older age group had higher P2 antibodies seropositivity of 84.2% which was significant (*P* value < 0.0001). A higher P2 antibodies seropositivity of 86.3% was found in children in Sabon Gari LGA and Palladan and Hayin Ojo (*P* value < 0.0001). Children whose fathers had secondary education and were civil servants had higher P2 antibodies seropositivity of 88.6% and 89.8% respectively. The highest P2 antibodies seropositivity was found in children with complete immunisation (96.0%).

9.3. P3 antibodies seropositivity

Age group, LGA, settlement, father's education, father's occupation, water source and immunisation history were significantly associated with antibodies to P3 serotype. Children in the older age group had a higher P3 antibodies seropositivity of 79.7% which was significant (*P* value < 0.035). Children in Hayin Ojo and Kofan Jatau, had higher P3 antibodies seropositivity of 86.6% and 74.9% respectively. Fathers with secondary education and civil servants had higher P3 antibodies seropositivity of 94.3% and 88.6% respectively, which were significant (*P* values < 0.0001 and 0.016) respectively. The highest seroprevalence rate to P3 was found in children who were fully immunised (97.3%), this value was significant (*P* value < 0.0001).

10. The relationship between vaccination history and antibodies seroprevalence to polio serotypes

The relationship between the vaccination history of children and antibodies seroprevalence to all polio serotypes (P1, P2 and P3) and combinations of polio serotypes is shown in Fig. 1. This showed an increasing trend in all polio serotypes with highest seroprevalence in children that were fully immunised and lowest in those that received no immunisation. These differences in all groups were statistically significant (*P* < 0.0001). Out of the 5 children that were seronegative for all the three polio serotypes, 4 were not immunised while 1 had partial immunisation.

11. Factors associated with polio antibody seropositivity using multivariate analysis

Using an unconditional multinominal logistic regression model, independent determinants of antibodies seropositivity to the

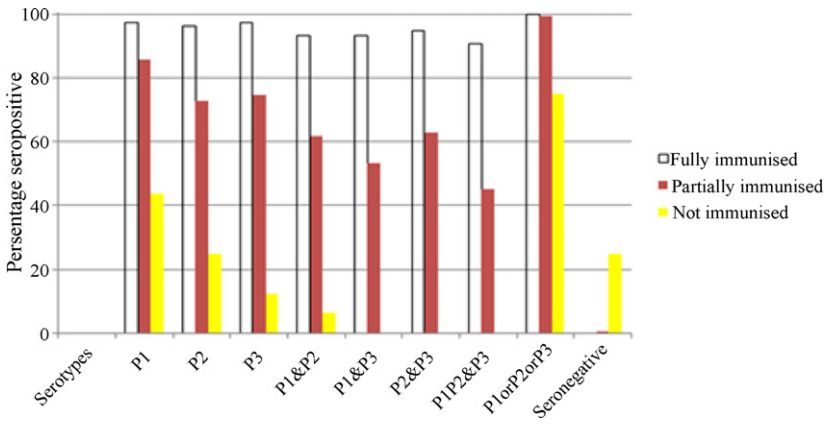

Fig. 1. Seroprevalence to polioserotypes in relation to immunisation history.

three polioserotypes were assessed. Table 4 shows the significant independent variables that were independently associated with antibodies seropositivity to the three polioserotypes.

Immunisation status and settlement were the only significantly independent determinants of antibodies seropositivity to the three polioserotypes.

12. Discussion

Results from this study on antibody response to polio serotypes amongst children in Zaria, shows that 55.3% of the children had antibodies to all the three poliovirus serotypes, 1.9% had no antibodies at all to the three poliovirus serotypes and 86.4, 76.1 and 77.3% had antibodies to poliovirus types 1, 2 and 3 respectively.

Seropositivity to the three polioserotypes in this study was found to be higher than the rates found in similar studies done earlier in Nigeria, but lower than the rates reported from studies done in other countries. Studies done in Nigeria [15,16] found seropositivity rates of 66.7, 71.4, 65.5% and 77.3, 86.4 and 76.1% to polioserotypes 1, 2 and 3 respectively while similar studies carried out in Egypt [17] and Saudi Arabia [18] found seropositivity rates of 99, 99 and 91% and 98, 96 and 94% to polioserotypes 1, 2 and 3 respectively in the studied population; with seroprevalence of 1 > 2 > 3 for the polio serotypes.

This study however, showed a seroprevalence of 1 > 3 > 2 for the polio serotypes amongst children aged 1–10 years in Zaria.

The new trend seen in this study could most likely be attributed to the recent introduction of monovalent vaccines by WHO in endemic countries to wipe out wild poliovirus types 1 and 3. WHO, introduced in 2005 more immunogenic and type specific monovalent vaccines mOPV type 1 (mOPV1) and mOPV type 3 (mOPV3) to combat outbreaks in countries where the wild type virus was still endemic [19]. The monovalent vaccines give a seroconversion of >80% with a single dose, which is a marked contrast to the conventional trivalent OPV t (OPV) [20] which requires at least three doses to achieve that same level of protection.

The low seroprevalence of type 2 antibodies is indicative of low routine immunisation coverage with tOPV. tOPV SIAs are the

Table 4
Factors associated with polio antibody seropositivity using multivariate analysis.

Variables	Serotype	OR (odds ratio)	95% CI	*P* value
	P1			
Children's settlement				
Kofan Jatau		4.57	1.18–17.5	0.027
Hayin Ojo		1.17	0.379–3.62	0.05
Palladan		1.165	0.43–3.15	0.05
Pan Madina		1	1	
Immunisation History				
Complete		27.6	4.58–166.8	<0.0001
Partial		6.17	1.98–19.2	0.002
None		1	1	
	P2			
Settlement				
Kofan Jatau		5.850	2.13–16.1	<0.0001
Hayin Ojo		2.811	0.95–8.3	0.061
Palladan		8.764	2.6–30.1	<0.0001
Panmadina		1	1	
Immunisation History				
Complete		41.7	6.8–256.9	<0.0001
Partial		6.3	1.7	0.006
None		1	1	
Age group				
1–5		0.3	0.2–0.7	<0.002
6–10		1	1	
	P_3			
Immunisation history				
Complete		180.8	19.4–1689.8	<0.0001
Partial		22.2	4.2–117.2	<0.0001
None		1	1	

primary sources of PV2 immunity for the at risk population in the northern states because the WPV type 2 has not been in circulation since 1999. PV2 immunity gaps widened with the emphasis on the use of mOPV1 and mOPV3 in SIAs [21] giving rise to the emergence and spread of cVDPV2. These findings are in line with recent studies suggesting that the key risk factor for cVDPV emergence and spread is low population immunity [22–24]. This is further corroborated by the findings of Wassilak et al. [21] which shows that the largest reported outbreak of cVDPV2 occurred in Northern Nigeria between July 2005 through June 2010, a period when 23 of the 34 SIAs used monovalent or bivalent oral poliovaccines (OPV) lacking Sabin 2.

The study also showed significant differences in seropositivity to the polioserotypes amongst the two local government areas. Sabon Gari LGA had a higher percentage of children seropositive to all the three polioserotypes as compared with Zaria local government. Amongst the settlements, Panmadina which is located in Zaria local Government had children with persistently low seropositivity to all the three polioserotypes. There were however, regional differences with regard to settlements with high seropositivity.

The low seropositivity of children in Zaria LGA could be attributed to socio-cultural and religious beliefs, and fear of the health consequences of the OPV vaccine on children. In a study done in Northern Nigeria, using Zaria as a case study [25] the resistance to the polio campaign was discussed in a broader socio-cultural and political context. Obadare [26] found that many people were genuinely afraid to risk having their children vaccinated, in part, because of the lack of trust in their government. The fact that the vaccine was provided free of charge and distributed by government to even the most remote communities heightened suspicions, as parents wondered why medicines and medical services for more common and deadly illnesses like malaria, cholera and diarrhoeal diseases were neither free nor easily accessible [27] while wariness is not uncommon in the developing world, this fear was further compounded in the aftermath of a controversial drug trial where Olusanya [28] noted in addition also, lack of informed parental consent, which occurred with the trial antibiotic Trovafloxacin mesylate developed by Pfizer during the 1996 CSM epidemic which resulted in the death of eleven children in Kano [29]. This reinforced a distrust of western pharmaceutical companies and western biomedicine. In Zaria, the consequences of these different opinions on the benefits and risks of the oral polio vaccine have been low turn outs for immunisation leading to high rates of incomplete or no polio immunisations. There was no significant difference in the sex distribution of polio antibodies amongst children in the study area. William and David-West [30] observed a similar pattern in their study of a population of vaccinated children in the southern and northern parts of Nigeria respectively. Thus, gender may not be important in determining immune response to poliovirus serotypes.

Socioeconomic status of parents (fathers' education and occupation) had a significant relationship with seroprevalence and antibody titres. Fathers who had secondary education had the highest percentage of children seropositive to the three polioserotypes. In Nigeria, more specifically in rural northern Nigeria, where most mothers are housewives with little or no formal education, what happens on the home front is solely determined by the fathers, with little or no contributions by the mothers. Thus, because of the knowledge and better understanding of the importance of immunisation, the tendency to accept and allow their children to be immunised is higher which is reflected in the results seen. Fathers who were civil servants also had the highest percentage of children seropositive to the three polioserotypes. Sabon Gari LGA which had a higher percentage of fathers with secondary education and fathers who were civil servants also had children with a higher seropositivity.

In the logistic regression table (multivariate analysis), immunisation status and settlement appeared to best predict high seroprevalence to the three polioserotypes. The data also suggests that immunisation status can predict OPV performance.

Fig. 1 shows that more than 90% of children who were fully immunised had antibodies to all the three polio serotypes and the different combinations (P1 and P2) (P2 and P3) (P1 and P3) of polio serotypes than those who had partial or no immunisation. All the children who had antibodies to at least one of the polio serotypes had complete immunisation. Out of the five children that did not have detectable antibodies to any of the 3 polio serotypes, 4 (%) had no history of immunisation and 1 (%) had partial immunisation. The finding above suggests that immunisation is the single most important determinant of seroconversion and antibody titre levels.

13. Conclusions

Antibody titration results from this study showed that less than two-thirds of the children studied in Zaria had antibodies to all the three polio serotypes. Seroprevalence to polioserotypes 1, 2 and 3 were 86.4%, 76.1% and 77.3% respectively and about 2% had no antibodies at all to the three poliovirus serotypes. There were pockets of under immunised and non-immunised children at the risk of infection with one or more poliovirus serotypes. Immunisation status and socioeconomic status of parents (fathers education and occupation) had a significant relationship with seroprevalence and antibody titres. High routine immunisation coverage with tOPV is necessary to prevent emergence and transmission of cVDPV2.

Acknowledgements

I would like to acknowledge the financial support from the University Board of Research, Ahmadu Bello University Zaria, Nigeria and Thank Dr. MM Baba, Mr. B. Oderinde, Mr. O. Ogunmola, Mr. M. Talle and the rest of the Staff of the National Polio Laboratory Maiduguri where the research was conducted.

References

[1] Global Polio Eradication Initiative. Bull WHO 2008;84(August (8)). Available at www.scielosp.org [retrieved January 2010].
[2] Wild poliovirus weekly update. Available at: www.polioeradication.org/casecount.asp [retrieved March 2010].
[3] CDC. Progress towards interruption of wild polio virus transmission – Worldwide, January 2011–March 2012. Morb Mortal Wkly Rep 2012;61(May (19)):353–7.
[4] CDC. Progress towards poliomyelitis eradication – Nigeria. January 2002–March 2003. Morb Mortal Wkly Rep 2003;52:567–70.
[5] Alyward RB, Hull HF, Cochi SL, Sutter RW, Olivé JM, Melgaard B. Disease eradication as a public health strategy: a case study of poliomyelitis eradication. Bull WHO 2000;78(3):285–907.
[6] CDC. Progress towards poliomyelitis eradication – Nigeria. January 2008–July 2009. Morb Mortal Wkly Rep 2009;58(41):1150–4.
[7] WHO Advisory Committee on polio eradication-standing recommendations for responding to circulating polioviruses in polio-free areas. Wkly Epidemiol Rec 2005;80:330–1.
[8] World Health Organisation. Global case count – the Global polio eradication initiative; 2006. Available at http://www.polioeradication.org/casecount.asp
[9] Ian Lewis New bivalent polio vaccine simplifies logistics in hard to reach areas. UNICEF supply division. Available at: http://www.technet21.org/forumv3/viewtopic.php [24.02.10].
[10] Progress towards poliomyelitis eradication. Nigeria, January 2010–June 2011. Morb Mortal Wkly Rep 2011;60(31):1053–7.
[11] World Health Organization Executive Board. Poliomyelitis: intensification of the global eradication initiative. Geneva, Switzerland: World Health Organization; 2012. Available at: http://apps.who.int/gb/ebwha/pdf_files/eb130/b130_r10-en.pdf
[12] UNICEF. The Game changer. UNICEF Quarterly Newsletter on Polio Eradication Initiative in Nigeria; June 2012. p. 8–9.
[13] Cooke JG, Tahar F. Polio in Nigeria; the race to eradication. A Report of the Centre for Strategic and International Studies Global Health Policy Centre; February 2012. p. 15.

[14] Baba MM, Haruna BA, Ogunmola O, Ambe JP, Shidali NN, Oderinde B, et al. A survey for neutralizing antibodies to the three types of poliovirus among children in Maiduguri, Nigeria. J Med Virol 2012;84(4):691–6.
[15] Aminu M. The epidemiological survey of the level and significance of antibodies to poliomyelitis virus. An unpublished M.Sc. thesis. Ahmadu Bello University, Zaria, Nigeria; 1999. p. 64.
[16] World Health Organization. Manual for the virological investigation of polio; 1997. WHO EPI/GEN/97.01.EP1.
[17] El-Sayed N, Al Jorf S, Hennesay KA, Salama M, Watkins MA, Abdelwahab JA. Survey of poliovirus antibodies during the final stage of polio eradication in Egypt. Vaccine 2007;25:5062–70.
[18] Farag MK, Al-Mazrou YY, Al Jefry M, Al-Shehri SN, Baldo MH, Farghali M. National immunization coverage survey, Saudi Arabia. J Trop Pediatr 1991;41(1):59–67.
[19] Caceres VM, Sutter RW. Sabin monovalent OPV vaccines. Review of past experiences and their potential use after polio eradication. Clin Infect Dis 2001;33:533–41.
[20] Grassly NC, Fraser C, Wenger J, Deshpanda JM, Sutter RW, Heyman DL, et al. New strategies for the eradication of polio India. Science 2006;314:1150–3.
[21] Wassilak S, Ali Pate M, Wannemuehler K, Jenks J, Burns C, Chenoweth P, et al. Outbreak of type 2 vaccine-derived poliovirus in Nigeria: emergence and widespread circulation in an underimmunized population. J Infect Dis 2011;203(7):898–909.
[22] Kew OM, Sutter RW, de Gourville EM, Dowdle WR, Pallansch MA. Vaccine-derived polioviruses and the endgame strategy for global polio eradication. Annu Rev Microbiol 2005;59:587–635.
[23] Rakoto-Andrianarivelo M, Gumede N, Jegouic S. Reemergence of recombinant vaccine-derived poliovirus outbreak in Madagascar. J Infect Dis 2008;197:1427–35.
[24] Kew OM, Morris-Glasgow V, Landaverde M. Outbreak of poliomyelitis in Hispaniola associated with circulating type 1 vaccine-derived poliovirus. Science 2002;296:356–9.
[25] Elisha R. Perspectives on polio an immunization in Northern Nigeria. Soc Sci Med 2006;63:1857–69.
[26] Obadare E. A crisis of trust: history, politics, religion and the polio controversy in Northern Nigeria. Patterns Prejudice 2005;39(3):265–84.
[27] US Embassy, Abuja, October Sitrep on Nigerian Polio Eradication Efforts, cable; October 29, 2008. http://wikileaks.ch/cable/2008/10/08ABUJA 2129.htm#
[28] Olusanya B. Polio vaccination boycott in Nigeria. Lancet 2004;363: 1912.
[29] Abdullahi vs Pfizer. Inc. 01 C1v.8118 (WHP). United States District Court for the Southern District of New York, 2005 U. S. Dist. (LEXIS) 16126; August 9, 2005.
[30] William JO, David-West TS. Poliovirus antibody in children from a paediatric hospital in Ibadan, Nigeria. Rev Rom Virol 1990;41:129–33.